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A Study of the Relationship Between the Amount of Fountain Solution Used on a Sheet-fed, Single-unit Offset Press and the Degree of Picking Encountered on Coated, Sheet-fed Offset Paper

Roger Lloyd Williams

A STUDY OF THE RELATIONSHIP BETWEEN THE AMOUNT OF FOUNTAIN SOLUTION USED ON A SHEET-FED, SINGLE-UNIT OFFSET PRESS AND THE DEGREE OF PICKING ENCOUNTERED ON COATED, SHEET-FED OFFSET PAPER

BY

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A STUDY OF THE RELATIONSHIP

BETWEEN THE AMOUNT OF FOUNTAIN SOLUTION USED

ON A SHEET-FED, SINGLE-UNIT OFFSET PRESS

AND THE DEGREE OF PICKING ENCOUNTERED

ON COATED, SHEET-FED OFFSET PAPER

This thesis is approved as a creditable, independent investigation by a candidate for the degree, Master of Science, and acceptable as meeting the requirements for this degree; but without implying that the conclusions reached by the candidate are necessarily the conclusions of the major department.

Thesis Advisor

Head of the Major Department

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CHAPTER I

INTRODUCTION

During the author's employment as Quality Control Pressroom supervisor for West Virginia Pulp and Paper Company's mill at Tyrone, Pennsylvania, the problem of picking on offset paper arose daily. Picking was the largest single cause for paper rejection from the pressroom. Although quality standards were high--a tremendous amount of paper never reached the printer--picking was still a major complaint among printers using the company's product.

A factor appalling to the author at this time was the general lack of information concerning the interactions of fountain solution, ink tack, and picking in the printing process. A consensus of people in the printing and paper industries seemed to be that the fountain solution of an offset press would have little or no effect on the degree of picking encountered on a single-unit, sheet-fed offset press.

During an information gathering trip to Wisconsin paper mills in October, 1967 this opinion was reiterated in interviews with Dr. Walter W. Roehr of Kimberly-Clark Corporation, Dr. Robert Leekley of the Institute of Paper Chemistry, and Mr. Donald Marks, Quality Control Pressroom Supervisor of a coated paper company which desires to remain anonymous.

While at Westvaco, the author conducted an experiment in which he printed a solid on a single-unit, sheet-fed offset press; the water fountain squeegees were positioned down on one half of the solid and up on the other half. This gave the same effect as running the press with two different fountain settings. This experiment showed conclusively that after 500 sheets were printed the side with less water picked considerably more than did the side with more water. The findings of that study, then, did not coincide with ideas expressed in interviews preceding this research project.

Purposes of the Study

The research conducted for this thesis was essentially a continuation of the previously mentioned experiment. The objectives of this experiment, however, were broader than were those of the first one. It was the writer's intention to bring together an array of specific facts concerning the problem of picking and combine them with an experiment to determine the effects of the amount of fountain solution used on the press and the propensity of a coated sheet of paper to pick. The greater the depth of inquiry into the problem of picking, the greater the cognizance of its enormity and nebulous nature. Little is concrete; much is theory. Dr. Werner Gerlach of Capitol Printing Ink Company had this to say about the interaction of ink, water and tack: "It is an area which will be studied for the next decade; perhaps, before it is readily understood."[1]

Review of Literature

According to Andries Voet, "picking under actual printing conditions (is) a complicated phenomenon, strongly influenced by paper, ink, plate, press and speed of printing."[2] Picking itself has many definitions. Voet states that "paper rupture in the printing process must be considered to occur when the energy density of the impacting wave exceeds the rupture energy density of the paper."[3] The most widely used definition for picking is the one expounded by the Technical Association of the Pulp and Paper Industry:

> Picking is any disturbance of the paper surface layers which occurs during the ink transfer process. The disturbance may take the form of fiber or coating lift, fiber or coating removal, blister or complete rupture of the paper. Picking is thought to result when the forces required to split an ink film are greater than the forces required to separate portions of the paper surface from its substrate.[4]

From these two definitions, one can surmise that the two most important factors influencing a paper's propensity to pick are the tack of the ink and the surface strength of the paper. Many volumes of technical facts and theory could be written about each.

The rheology of printing inks, which is the scientific study of flow characteristics, is an extensive area. Tack is not a constant, but a product of the ink's rheological properties. These are determined by the chemical and physical properties of the vehicle; the chemical, physical, and colloidial properties of the pigment and extenders; the per cent of solids to liquids and the thixo-tropic characteristics.[5] "Tack itself is generally accepted as the resistance of the ink film to splitting. It is really a measure of internal cohesion of the material."[6]

Tack is a dynamic characteristic of printing ink that changes with environmental conditions, age of the ink, press speeds, etc. The reactions of printing ink's tack to thermal conditions is particularly important. Tack and temperature are inversely related. "A 1°C rise in the temperature of an ink causes a 9 per cent drop in its viscosity. Many who have made a study of ink rheology believe that tack and viscosity are closely related, if not synonymous."[7] This is probably why picking is often more prevalent during the beginning of a press run than at the end. The ink is cold and stiff, but after running the press for awhile, frictional heat builds up in the ink, rollers, roller journals, and bearings which results in a sometimes significant decrease in tack.

For many years printers and ink makers believed they understood the nature of tack quite well. This belief was based on the Stefan equation of 1874 which stated:

$$F = \frac{3\ Z\ O}{4\ t\ h^2}$$

F--Force necessary to separate two inked plates
Z--Viscosity (in poises) of ink between the plates
O--Plate Area
t--Time of separation (essentially the same as printing speed)
h--Distance between plates (ink-film thickness)[8]

The Stefan equation is now believed to hold true at low printing speeds, (approximately 300 ft/min.). At higher speeds, however, ink behaves in a different way. At these speeds ink behaves like an "elastic solid."[9] The effective tack of the ink increases as the speed of the press increases; the degree of this change is determined by the ink's stability.

Ink-tack-water interrelationships have been studied with conflicting results. J. Albrecht and M. Heigl of Deutche Gesellschaft fur Forschung im Graphishen Gewerbe (FOGRA) concluded that the amount of fountain solution absorbed by offset inks through emulsification is an interaction between the vehicle type, the chemical and physical properties of the pigment, and the volume fraction of the pigment contained in the ink.[10] The hydrophilic and hydrophobic properties of the pigment also play an important part in the ink's affinity for water. For these reasons inks having different compositions have different abilities of emulsification.

> Some inks, such as those based on high melting phenolics, cyclicised rubber or petroleum resings, pick up only six or eight per cent of water. Straight linseed oil and some long oil alkyds pick up 20 to 25 per cent of water and continue to print normally.[11]

Albrecht and Heigl's experiments "showed an increase in tack with emulsification and a corresponding increase in picking properties."[12] Otto C. Stoessel Jr., after testing the effects of water on tack with an L. T. F. Inkometer (an industry accepted tack-measuring instrument) stated that after emulsification, "A good ink will read about the same or within plus .2 to a minus figure. A poor ink will read plus .5 to plus 4.0 and over."[13] Charles Latham of what was then known as the Lithographic Technical Foundation stated that as a result of ink water emulsification, "ink becomes less fluid, stiffens up, loses its flow, loses its tack will not transfer properly from rollers to plate . . . ."[14] William Enchelmeyer, Lithographic Products Manager of Borden Chemical Company found that, "Normally, as the amount of water is increased emulsification begins to take place to a marked degree and the tack of the ink will decrease accordingly."[15]

As mentioned earlier, the components of the ink determine its reaction to water emulsification, but generally speaking, and for commonly used offset inks, "The dampening solution which forms an ink and water emulsion of the ink, decreases the tack measurement."[16] Emulsification, which is necessary to a certain degree to maintain a sharp-printed image, can be found in three states:

(1) The water does not attach itself to the pigment surface but instead, forms a water-in-oil emulsion.

(2) The water replaces a portion of the vehicle on the surface of the pigment, which also results in a water-in-oil emulsion.

(3) The water can replace all or nearly all of the vehicle on the pigment's surface. Thus, the ink shifts to an oil-in-water emulsion.[17]

The best ink would be found somewhere in the first state. This would be an ink that "emulsifies a medium amount of water . . . and still leaves only a small amount of surface moisture on the ink."[18]

To this point the discussion of the ink-water-tack relationship has excluded the effects of the chemical composition of the fountain solution. There is a tremendous variance in these chemical compositions from plant to plant. There are more than ten different types of stock solutions on the market to be mixed with water only or with water and gum. Also, there are various fountain formulas which can be completely mixed by the lithographer. For example, Graphic Arts Technical Foundation offers two formulas which contain various chemicals. One is comprised of gum arabic, phosphoric acid, and ammonium bichromate; the other contains cellulose gum, phosphoric acid, and zinc nitrate.[19] According to GATF, the necessity and purpose of the ingredients used in solutions must still be determined.[20]

The use of alcohol as a wetting additive in fountain solutions is also becoming increasingly prevalent. The effects of solution composition and fountain pH on the tack properties of ink have not been fully investigated as yet.[21] The generally expressed opinion of ink manufacturers in their letters to the author was that, "Ink tack is affected by the pH of the fountain solution and other components only in the degree that they affect the ink/water balance."[22] In contrast, the National Association of Printing Ink Manufacturers states that, "The nature of the fountain solution greatly affects the working property of the ink being used. Too much acid retards drying and causes roller stripping--too much gum encourages emulsification."[23] The information available about the water-ink interaction is confusing and offers an excellent area for future research.

The ink transfer properties of the printing blanket are also extremely important to the relationship of the ink to the paper. It is at this point that picking either does or does not occur. The blanket's properties can either contribute to the problem of picking or lessen the propensity of a sheet of paper to pick. The degree of resistance of the printing blanket to solvents is extremely influential in the actual transfer of the ink film from the blanket to the paper. Charles Borchers and William L. Boehm found, "that on a standard blanket, a film of quickset ink 9 microns thick could undergo a 100 per cent increase in tack in six minutes."[24] This increase in tack was found to be the result of ink vehicle absorption into the blanket's surface. "Blankets having higher solvent-resistant compositions have better ink release than those with lower solvent resistance."[25]

Another factor contributing to picking is the suction and friction effect of the smooth, resilient surface of the blanket on the sheet of paper. The intimacy of the blanket to the printed sheet is of great importance in the actual process of transfering ink from the blanket to the paper. The actual ink transfer has been studied considerably but not fully understood. The relationship between ink, blanket and paper is explained in the following manner in the Penrose Annual of 1957:

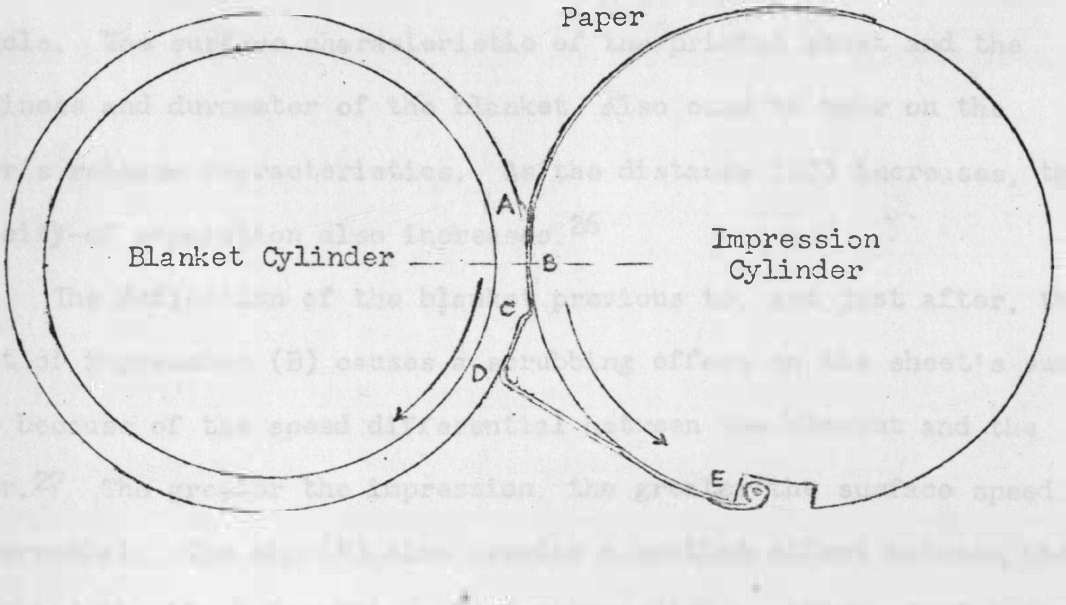

FIGURE 1

Ink Transfer Process on a Sheet-fed Offset Press

From (A) to (B), the nip between blanket and impression cylinder, there is a build up of pressure that impresses ink, paper, and blanket. As the paper passes point (B) these compression forces are reduced and finally released at point (C). The paper, however, clings to the blanket between (C) and (D). Tension forces are then developed in the ink, paper, and blanket when the grippers (E) pull the paper from the blanket.

The force required to split the ink film depends mainly on the tack of the ink and the speed of the press. These are the main factors that determine how long the paper continues to follow the blanket from point (C) to (D) or what the exact distance (CD) becomes. This, in turn, determines the speed and angle at which the paper is stripped away from the blanket at point (D). Another factor is the length of time the sheet is in the nip (AC), which is a combination of speed and pressure; this affects the paper's absorption of ink vehicle. The surface characteristic of the printed sheet and the tackiness and durometer of the blanket, also come to bear on the paper's release characteristics. As the distance (CD) increases, the velocity of separation also increases.[26]

The deflection of the blanket previous to, and just after, the point of impression (B) causes a scrubbing effect on the sheet's surface because of the speed differential between the blanket and the paper.[27] The greater the impression, the greater the surface speed differential. The nip (B) also creates a suction effect between the paper and the blanket. This, along with a high coefficient of friction of the blanket's surface composition, enhances the picking condition.[28]

Thus far, mention has been made of the water-ink-tack relationship, the ink-transfer process, the blanket's properties, and other variables that affect picking, but nothing has been mentioned about the actual pickouts. Picking on coated paper is usually classified by origin according to the shape and depth of the actual point of rupture. Generally, they are classified according to causes established by the depth of the rupture, as indicated in figure number two.[29]

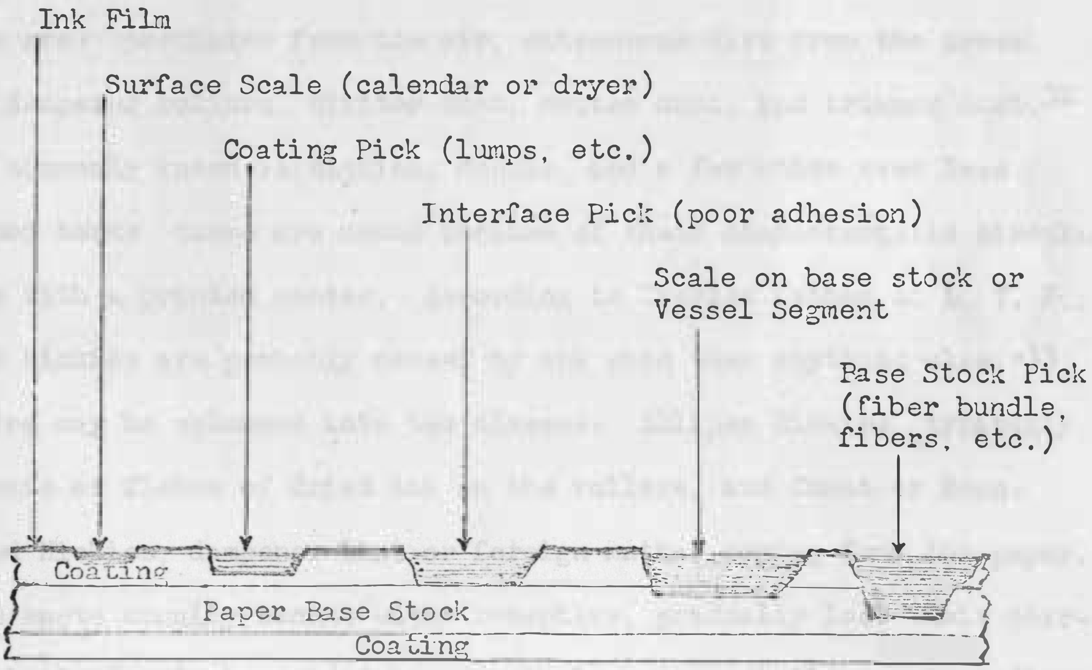

FIGURE 2

Criteria for Classifying Pickouts on Coated Paper

The reader should not be misled into believing that the picking samples, to be presented later, cover the full range of picking defects possible. There are almost as many causes of picking, from the papermaker's viewpoint, as there are ingredients and procedures in the papermaking process. Also, this study deals only with sheet-fed coated offset papers and does not touch the area of uncoated papers nor the processes of letterpress or web offset printing.

The problem of "pseudo picking"[30] should be mentioned before discussing actual picking because of its frequent confusion with the topic of this thesis. Pseudo picking is identified as "small islands of stock over which the ink has not been held by the paper or has not properly contacted the paper during printing."[31] Some causes of such spots are: particles from the air, extraneous dirt from the press, ink, dampener rollers, slitter dust, cutter dust, and trimmer dust.[32] More commonly known as hickies, donuts, and a few other even less refined terms, these are named because of their characteristic circular shape with a printed center. According to Charles Latham of L. T. F., "more hickies are probably caused by ink skin than anything else."[33] Hickies may be subsumed into two classes: Ellipse Hickies, typically ink skin or flakes of dried ink on the rollers, and Comet or Moon-Shaped Hickies, dampener lint or foreign matter coming from the paper. These spots usually become water receptive, gradually lose their characteristic donut shape, and become simply a non-printing spot or disappear on their own accord.[34]

In contrast to pseudo picking, true picking always involves a rupture or partial rupture of the printed sheet. Secondary pickouts, secondary spots, or repeats are non-printing spots caused by debris from an actual pickout. Some secondary pickouts will cause donut-type spots at first, but will gradually become water receptive and reproduce as simple voids.

The following picking samples were photographed at 50 power unless otherwise indicated, by a polaroid-mounted microscope with a high intensity, low-angle light on the subject. Because of the low angle, a shadow effect causes some of the samples to appear to be above the surface of the sheet. All samples were collected from a single-unit, sheet-fed offset press using coated paper and represent actual pickouts which might confront an offset pressman. The picking samples and descriptions were donated by West Virginia Pulp and Paper Company and by another paper company which asked to remain anonymous. The anonymous company will henceforth be referred to as company X. West Virginia Pulp and Paper Company will be referred to by its trade name of Westvaco.

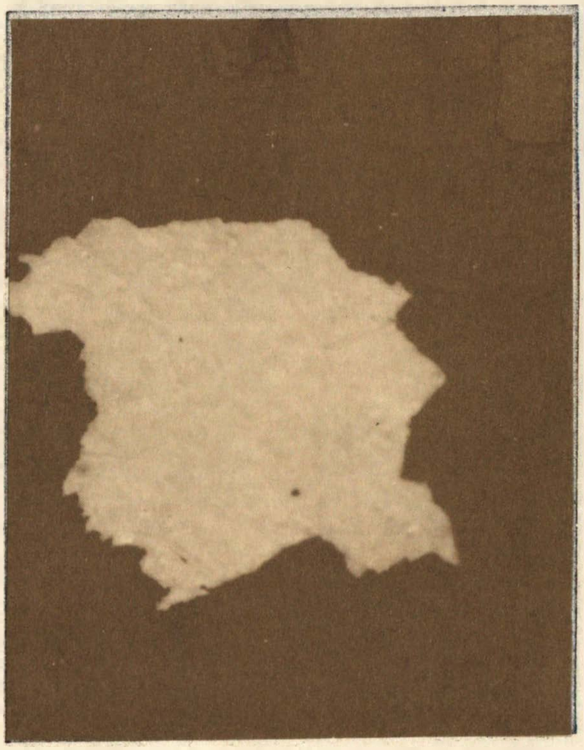

PLATE A

Flakes

Flakes are thin, flat particles, irregular in shape, which generally leave voids with no coating breaks. These flakes may or may not be embedded in the coating and are analogous to scale but are not visible on the opposite side of the sheet. They cause repeat spots and are found randomly over the sheet. Flakes are usually neither transparent nor translucent and are easier to see than scale when viewed at an oblique angle.[35]

PLATE B

Loose Scale

Loose scale or foreign material from the dryers or supercalender is placed on the sheet after the coating, then pressed deep into the coating layer. The crater does not extend down to the raw stock. Loose scale pickouts are often caused by dryer scale, dryer dirt, or calender scale. They are found randomly on the sheet and after picking out often become ink receptive and appear similar to hickies. The particles on the unprinted areas of the sheet are shiny and translucent.[36]

PLATE C

Picking Streaks

These pickouts appear in a line running in the machine direction of the sheet. They are most frequently caused by the drying of coating on the last section dryer drums. This dried coating scratches the surface of the sheet causing a poor coating bond. The streaks are usually localized in a particular area of the sheet and are seldom found on both sides of the sheet simultaneously.[37]

PLATE D

Secondary Pickout Caused By A Felt Hair

This particular sample is a secondary or repeat pickout. The dryer felts of the paper machine are the source of these fibers. Depending on whether the felt that is shedding is situated before or after the coating process, the fibers are either on the surface of the raw stock or the surface of the coating. In either case there is a poor coating bond and a pickout will usually occur during the printing process. Felt hairs are much longer than pulp fibers and will cause secondary spots.[38]

PLATE E

Coating Lump

Coating lumps are small, hardened-coating particles pressed into the sheet, generally on the felt side. Its pickouts leave small, uniform, and sometimes rectangular-shaped craters. Normally no fibers are exposed. The caliper of the spot is thicker than the surrounding areas. These spots are visible on both sides of the sheet as shiny translucent areas. They are found randomly and will cause secondary pickout spots.[39]

PLATE F

Lifting

Lifting is a picking defect caused by bonding weakness, resulting in a medium-roundish crater. Characteristically, fibers are exposed at the bottom of the crater, although fibers often extend from the edge of the crater as well. These pickouts are found randomly over the sheet and will cause secondary spots.[40]

PLATE G

Scale Between the Base Stock and the Coating

These pickouts are caused by foreign material between the base stock and the coating, resulting in a poor bond. The coating lifts easily, leaving a crater-shaped area without disturbing the base-stock fibers. These are usually found randomly on a sheet and will cause secondary spots.[41]

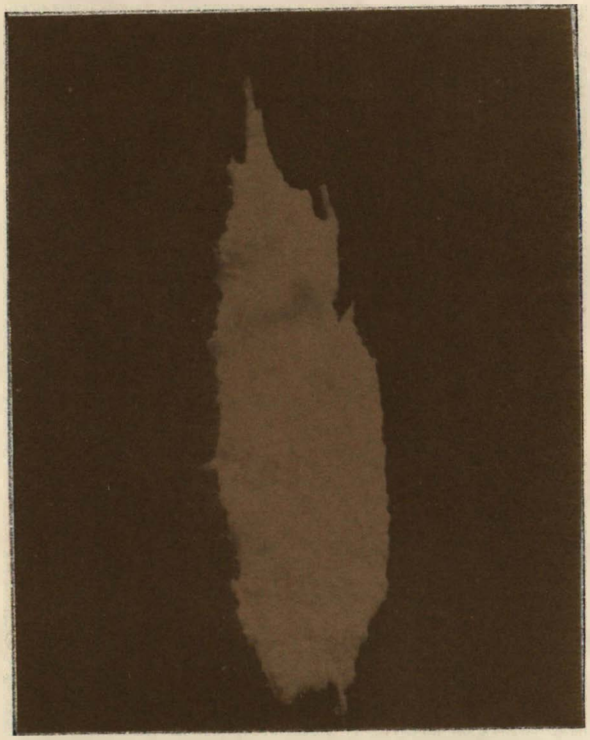

PLATE H

Coating Pick

Coating pick is caused by poor adherence of the coating to the base stock. Improper coating or sizing formulation can cause large areas of coating to pick easily. The edge of the crater is ragged. The creater extends to the base stock but the fibers are not usually disturbed. Coating picks are found randomly and will cause secondary spots.[42]

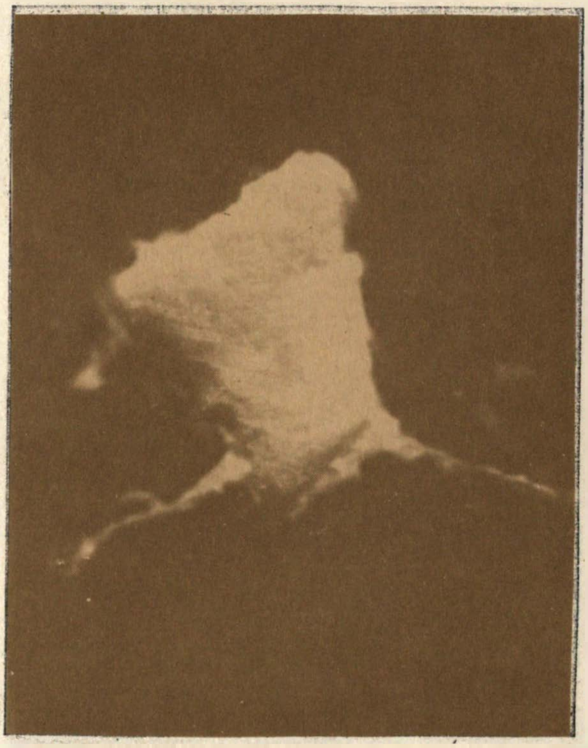

PLATE I

Vessel Segment

Vessel segments are fibrous materials from the pulpwood found mostly in hard woods such as oak, birch and maple. They are wider than normal pulp fibers and tend to float to the surface of the furnish while the slurry is on the wire. For this reason they are found mostly on the felt side and do not form a good bond with the other fibers. They are not patterned and at times the pickout becomes ink receptive and the secondary spots appear as hickies or donuts.[43]

PLATE J

Shive

A shive is an oblong chip or sliver, loosely bound into the base stock. When picked out, it leaves a long, narrow crater with exposed fibers. Because shives have a tendency to float, they are usually found on the felt side. They are not found in any particular pattern. In the non-image areas of the sheet they have a brown appearance. The pickouts will repeat as secondary spots.[44]

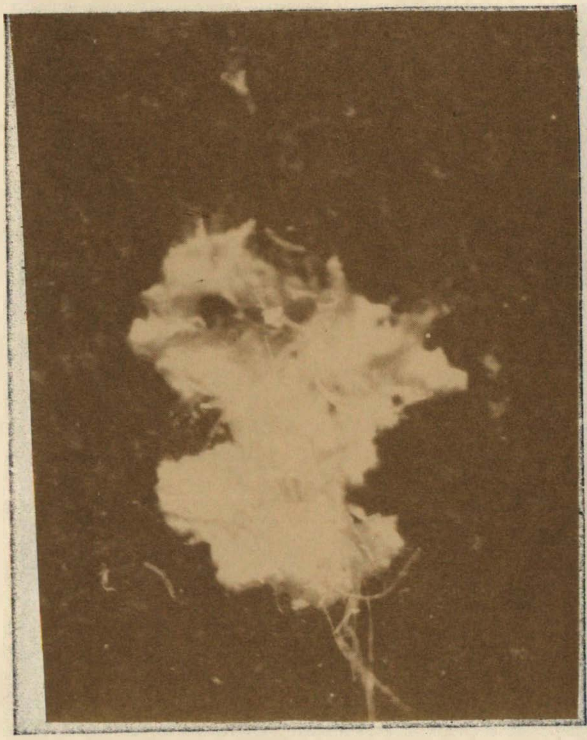

PLATE K

Fiber Bundle

Fiber bundles are undispersed pulp fibers that collect together. The bundle does not bond well with the other fibers of the sheet. These are relatively large pickouts that are not found in any particular pattern; they will cause secondary spots.[45]

PLATE L

Delamination

Delamination occurs almost always in heavy solid areas, seldom in halftones, and never in unprinted areas. The sheet is rough and has an appearance similar to heat blistering on web offset.[46] The example shows the splitting of the base stock. Delamination is an internal bond problem rather than a surface strength problem. There is no pattern and there are no secondary spots because of the lack of complete rupture.[47]

PLATE M

Shiner

A shiner is an aggregation of bacterial slime or other foreign matter within the base stock. When printed, the agglomerate will pickout leaving surrounding fibers undisturbed. The defect occurs randomly, will repeat, but is not common. In non-image areas shiners appear as silvery, translucent spots.[48]

The information that has been presented is not complete; it does not presume to cover the entire subject of offset picking on sheet-fed coated paper. It does, however, serve as a comprehensive introduction to the problem and as a springboard to the upcoming experiment concerning the relationship of the amount of water used on the press and the degree of picking encountered. As can be seen readily, this is an extremely vague and unexplored area that is in need of a great deal of research.

LITERATURE CITED

1 Dr. Werner Gerlach, Capitol Printing Ink (letter to the author, September 28, 1967).

2 Andries Voet, Ink and Paper in the Printing Process, (New York, Interscience, 1952) p. 153.

3 Voet, p. 153.

4 Anonymous, "Surface Strength Terminology," Technical Association of the Pulp and Paper Industry, Publication Number 399.01, 1965, p. 3.

5 Joseph G. Curado, Sun Chemical Corporation (letter to the author, September 27, 1967).

6 William Enchelmeyer, Borden Chemical Company (letter to the author, October 11, 1967).

7 Curado, letter.

8 Carl B. Blake, Sinclair and Valentine Ink Company (letter to the author, October 6, 1967).

9 Blake, letter.

10 J. Albrecht and M. Heigl, "Water, Ink and Tack," TAGA Proceedings, 17th Annual Meeting, (Rochester, New York, Technical Association of the Graphic Arts, 1965) p. 337.

11 Curado, letter.

12 Albrecht and Heigl, p. 345.

13 Otto C. Stoessel, "Measurement of Ink and Printing Qualities," TAGA Proceedings, 12th Annual Meeting, (Rochester, New York, Technical Association of the Graphic Arts, 1960) p. 88.

14 Charles Latham, Advanced Pressmanship--Sheet-Fed Presses, (New York, Lithographic Technical Foundation, 1963) p. 174.

15 Enchelmeyer, letter.

16 William Yochheim, "What Printers Should Know About Uncoated Offset Papers," Inland Printer/American Lithographer, November 1964, p. 54.

LITERATURE CITED (continued)

17 Louis M. Larsen, Industrial Printing Inks, (New York: Reinhold Publishing Corporation, 1962) p. 254.

18 Paul J. Hartsuch, Chemistry of Lithography, (New York: Lithographic Technical Foundation, 1961) p. 248.

19 Hartsuch, p. 301.

20 Hartsuch, p. 301.

21 Blake, letter.

22 Enchelmeyer, letter.

23 Anonymous, Printing Ink Handbook, (New York, National Association of Printing Ink Manufacturers) p. 25.

24 Charles Borchers and William Boehm, "Current Studies of Ink Transfer to Paper in Lithography," TAGA Proceedings, 11th Annual Meeting, (Rochester, New York, Technical Association of the Graphic Arts, 1959) p. 37.

25 E. A. Clifton, Dayco Corporation (letter to the author, October 10, 1967).

26 Charles Borchers, "Studies of Ink Transfer to Paper in Lithography," The Penrose Annual, (London, Percy, Lund, Humphries & Company, Ltd., Vol. 51, 1957) p. 80.

27 Walter W. Roehr, Kimberly-Clark Corporation (personal communication, October, 1967).

28 Clifton, letter.

29 Peter K. Sacksen, Weyerhauser Corporation (personal communication, December 1966).

30 D. H. Stubbs, "Pick," American Ink Maker, March, 1966, p. 30.

31 Stubbs, p. 30.

32 William Byers, "Offset-Litho Questions, Contamination Problems," Graphic Arts Monthly, July, 1965, p. 108.

33 Latham, p. 203.

34 Oscar Diehl, "How Offset Printers Can Avoid Hickies," Inland Printer/American Lithographer, October 1964, p. 58.

LITERATURE CITED (continued)

35 Company X. Quality Control Data, 1967.

36 Company X

37 Company X

38 West Virginia Pulp and Paper Company, Quality Control Data, 1967.

39 West Virginia Pulp and Paper Company

40 Company X

41 Company X

42 Company X

43 West Virginia Pulp and Paper Company

44 Company X

45 West Virginia Pulp and Paper Company

46 Anonymous. "Technical Service Bulletin," (Pittsburgh, Pennsylvania, Graphic Arts Technical Foundation, August 1967) Vol. I, #1, p. 1.

47 Company X

48 West Virginia Pulp and Paper Company

CHAPTER II

METHODOLOGY

The primary objective of the equipment and procedures used was to keep all variables as constant as possible with the exception of the varying amounts of fountain solution. This required a consistency in methods, materials, evaluative procedures and all of the variables that might have had an effect on the outcome of the experiment. Complete control of offset press variables is impossible; for one thing the press is a machine, not an instrument. Although precise settings can be made and consistency can be maintained to a point, there are inherent variables which must be realized before performing any experiment on a piece of equipment of this nature. The keywords are "as constant as possible." In this light, extreme care was taken in the selection of blankets, ink, pressures, fountain solution, paper, press speed and other factors relative to picking.

The Press

The press used for the experimentation was a 29-inch single-color Miehle offset equipped with standard pressure, and ink and water fountain controls. The amount of ink released from the fountain of the press is controllable through a ratchet which determines the length of dwell between the ink fountain roller and the ductor roller, and also by fountain screws which adjust the amount of ink that passes between the fountain roller and the fountain blade. The fountain screws adjust the amount of ink across the press. The ink settings used in the experiment were established by trial runs before any picking tests. The proper amount of ink was determined by visual analysis by three experienced printers, Phil Weeks, the pressman; Jon Braswell and the author. After the fountain was set there were no changes during the tests.

The water fountain works on a principle similar to the ink fountain. There is one water form roller, a chrome-coated vibrator roller, a ductor roller and a canvas-covered water fountain roller. The amount of water transferred from the water reservoir is determined by the dwell of the canvas covered water fountain roller while in contact with the ductor roller. This is determined by a ratchet adjustment which establishes the amount of revolution of the fountain roller. Through this adjustment the amount of water was varied from a low setting of 3 to a high setting of 11. This progressively increased the revolution of the fountain roller while in contact with the ductor roller, thus, increasing the amount of fountain solution transferred to the printing plate.

One advantage that the Miehle press has over other single-unit offset presses, as far as tests of this nature are concerned, is its feature of "True Rolling" cylinders. During impression on other offset presses the pressure between the blanket cylinder and the plate and impression cylinders causes both a reduction of the radius and an increase in the circumference of the blanket cylinder. With "True Rolling" the blanket cylinder is smaller in diameter than the plate and impression cylinders. When the cylinders are packed correctly this results in less of a depression in the blanket and more equal surface speeds of paper and blanket.[49]

The ink and water form rollers and vibrators were adjusted for proper contact with the plate and vibrator rollers before any tests were made. This was done to ensure uniformity of ink distribution throughout the tests. Proper contact in this case means even pressure from one end of the roller to the other as well as around the roller. A roller stripe of ink 1/8 inch to 1/4 inch thick on the printing plate was maintained on all the form rollers. An equal amount of pressure was maintained on the water form rollers as well. Properly set rollers are very important to the maintenance of a constant amount of ink being transferred to the plate.

The Plate

Ronald C. Reph of Minnesota Mining & Manufacturing Company (3-M) suggested the use of a 3-M type "K" offset plate for a test of this nature because of its "large range of water acceptancy while still maintaining a good solid."[50] The 3-M type "K" plate belongs to the subtractive family of plates because exposure to light hardens the image areas; and during processing the non-image areas are washed away. It is a stable plate made for longer runs than the additive type plates such as type "R", and is less susceptible to the effect of fountain solutions, wash-up solutions, printing pressures and other factors which shorten the effective life of plates.

As with the blanket, the plate was packed to Miehle specifications to maintain a "True Rolling" surface.

Design of the Plate

The test plate was functionally designed for the picking test, both for a quantitative pick analysis and a qualitative print analysis. The solid 6 x 12 inches was designed exclusively for picking analyses. The halftones on either side of the solid were for rapid visual analysis during the set-up period to facilitate proper adjustment of the ink and water systems. The GATF star targets and slur scales were positioned on the plate to determine any slippage of the sheet during impression that might affect the degree of picking. The GATF quality strips, fill-in scales, and star targets were used to both set up the inking system properly and to determine the effects of the changing water balance.

The Paper

Perhaps the most critical component of the test was that of the paper. It was 60-pound Velvo Litho Gloss, a high quality, coated-two-sides, enamel supercalendered sheet. Specifications as requested were for a coated sheet-fed offset paper that passed all requirements related to picking, but was rejected for picking. This rejection was based on mill specifications of any total "area of pickouts" count above 3.5 square millimeters counting all spots .01 square millimeters in size and above in a printed solid approximately 6 x 14 inches. This specification was necessary to obtain a sheet of paper that would pick.

and would react more readily to changing press conditions. Also required was the complete absence of scale. This was important because scale is usually scattered randomly and may pick in one sample but not in another. The paper was all cut from a single roll to minimize differences across the paper-making machine. The paper was received in October and remained on the skid until December to allow it to adjust fully to the atmospheric conditions of the printing laboratory.

The Ink

The ink used was Offset Jax Blue, manufactured to tack specifications for Westvaco's Quality Control Department for testing purposes. This batch was made to tack specifications of 15.0, medium speed. According to printing industry standards this would be a medium tack ink. It contains a linseed oil vehicle which has a relatively large latitude of water receptivity before breaking down. It also has no drier, which lessons the formation of ink skin and alleviates the problem of tack increase with age as a result of the action of the drier. A tack and stability test was performed at the Graphic Arts Technical Foundation just prior to the experiment. The results of this test showed that the tack had increased to 16.4 from the time of manufacture to the time of use. A 1.9 per cent increase in tack over a ten-minute period on the inkometer showed that the ink was very stable. Stability with the addition of water showed a decrease of 1.0 per cent which is also considered very stable.

The Blanket

Of the blankets donated for the experiment, the Dayco SB 140 experimental blanket that is coated to be highly impervious to solvents was used. This blanket was chosen over others because it has a lesser reaction to solvents during washup and a more consistent printing surface could be maintained throughout the tests. This consistency resulted in uniform impression from test to test because there was no swelling. Also a factor in selecting this blanket was the fact that it would not absorb ink vehicle as readily as would other blankets. Therefore, the effects of increased tack as a result of ink vehicle absorption were lessened. The blanket was packed to press specifications of approximately .004-inch impression between plate and blanket and between blanket and printed sheet. During the set-up run the blanket packing was checked to determine if there was any smashing down. These checks were made with a Colight gauge, a packing determination instrument that measures printing pressure without disturbing the plate or blanket. The packing of the plate and blanket previous to the test totaled .0045-inch impression. The packing at the conclusion of the test registered the same .0045-inch impression. Hence, no packing adjustment was necessary.

The Fountain Solution

Extremely important to this experiment was the type of fountain solution used, particularly its consistency throughout the tests. For this reason, enough solution for the entire experiment was mixed in a single batch. Distilled water was used in the initial mixture. The solution was adjusted to a pH of 4.0 with the addition of two quarts of tap water to two gallons of fountain solution. A pH of 4.0 to 5.0 is considered by Graphic Arts Technical Foundation as the most desirable pH range on a press of this type. The fountain solution used was recommended by GATF and is the same formula used by that organization in much of its research work. The formula is as follows:

Solution A	U. S. Units
Water	32 ounces
Ammonium Bichromate	$1\frac{1}{2}$ ounces
Phosphoric Acid, 85 per cent.	3/4 ounce

Solution B	
Magnesium Nitrate	16 ounces
Water to make	1 gallon

Press Fountain Solution	
Solution A.	1 liquid ounce
Solution B.	2 liquid ounces
Gum Arabic, 14° Baume	2 liquid ounces
Water	2 gallons[51]

The Testing Procedure

The press was washed prior to inking to assure a clean ink train. A new dampener sleeve was installed to maintain a clean water system. As much dust, dirt, and anti-offset spray as possible were removed to lessen the chance of outside contaminants. The room temperature and humidity readings at the beginning of the experiment, 9 a.m., were 70° and 33 per cent relative humidity. The room temperature and humidity readings at the end of the experiment, 4:30 p.m., were 74° and 32 per cent. This is representative of the temperature and humidity conditions of the printing laboratory during the fall season.

The old blanket was removed from the press and the Dayco SB 140 was put on according to manufacturer's specifications. The packing was checked by the colight gauge to be .0025 inch below the cylinder bearers.

All the skin was removed from the ink before placing it in the fountain. The fountain was set according to light and heavy areas of the form. Care was taken to place enough ink in the fountain to last the entire test.

Enough fountain solution was placed in the reservoir to ensure a sufficient amount for the complete test. As a double check, a second pH reading of the fountain solution was made immediately prior to beginning the test. Its results were 4.0 pH. This pH test was made with pHydrion papers made explicitly for fountain-solution testing.

The test plate was positioned on its proper cylinder with the correct amount of packing equaling .007 inch above the cylinder bearers. This was checked and confirmed with the Colight gauge.

At this point, the press was inked and let run at a speed of 6,000 impressions per hour for approximately thirty minutes. This was done to break the ink's consistency down properly and to build up frictional heat in the ink rollers, and bearings resulting in a heat/viscosity equilibrium.

During the time the press was warming up, the paper was placed on the press. The paper samples were randomized the previous day according to the following procedure. The sheets were separated into lifts of fifty; each lift was assigned a number, starting at the top of the skid and numbering consecutively to the bottom. The number seven was picked randomly and the lifts were numbered again every seventh lift so that a single press test would be composed of paper from random places in the skid. This was done to further ensure a consistent paper from test to test by randomizing any discrepancies that may have been present in the papermaking machine direction. A more complete description of the randomizing procedure may be found in Appendix E.

At this point, the press was stopped and the blanket checked again for correct packing. There was no correction needed, and the first test with the lowest water setting was ready to run. The fountain solution was progressively increased in order to allow a gradual build-up of water in the ink. Going from a minimum of water to a maximum amount of water allowed greater control of this variable because of the inability to remove all of the emulsified water from the ink between tests. The water fountain was turned on and the fountain roller was turned four times before each test. This provided enough water to ensure a clean start. The press speed was set at an arbitrary speed--6,000 impressions per hour. The counter was set at zero. The three hundred sheets of sample one were printed without making a change. The printed sheets were removed from the press and covered to prevent contamination. Pick analyses were done the next day, after completion of the press portion of the experiment, so that accurate, unhurried analyses could be made. At the completion of test one another packing check was made which revealed no change from the beginning of the experiment.

Sample two was printed in a like manner. The press was run ten minutes between runs with the ink and water turned off, the plate and blanket were washed and the three hundred sheets of the sample were printed. The water fountain was set at three. Samples two thru ten were printed on the opposite side of the sheet than sample one. This was done to obtain more picking than occurred during the printing of sample one. A packing check showed no change from the beginning of the experiment.

Sample three was printed with a water fountain setting of four. The press was run ten minutes between tests with the water and ink turned off. the plate and blanket were washed clean. the water fountain roller was turned four times to ensure a clean start, and three hundred sheets were printed. A packing check was made at the completion of the run and showed no change in either the plate or blanket.

Sample four was printed with the water fountain set at five. The press was let run ten minutes between tests with the ink and water turned off. the plate and blanket were washed, the water fountain roller was turned four turns. and three hundred sheets were printed.

Sample five was printed with a water fountain setting of six. The press was let run ten minutes with the ink and water turned off. the plate and blanket were washed, the fountain roller was turned four times, and three hundred sheets were printed.

Sample six was printed with the water fountain set at seven. The press ran ten minutes with the ink and water turned off, the plate and blanket were washed, the fountain roller was turned four times, and three hundred sheets were printed. No packing checks were made on samples four, five, and six because of the consistency maintained to this point.

Sample seven was printed with the water fountain set at eight. The rest of the test was performed the same as previous tests. A packing check was made which resulted in identical readings as those at the beginning of the experiment.

Sample eight was printed with the water fountain set at nine. All other settings and procedures were identical to those used in previous tests. No packing check was made.

Sample nine was printed with a water fountain setting of ten. All other settings and procedures were identical to those used in previous tests. No packing check was made.

Sample ten was printed with the water fountain set at eleven. All other settings and procedures were identical to those used in previous tests. A fountain solution pH test showed 4.0 which was consistent with the pH at the beginning of the experiment. A packing check also showed no change from the beginning of the experiment. A temperature and humidity check showed 74° and 32 per cent relative humidity. The net change from the beginning to the end of the experiment was an increase of 4° temperature and a decrease of 1 per cent relative humidity.

All samples were set aside for later quantitative pick analysis. This analysis consisted of a "number of pickouts" count on the last sheet printed and every fiftieth sheet preceeding until four sheets were counted. A "number of pickouts" count was used in order to eliminate the possibility of a single large pickout or a great many very small pickouts adversely affecting the correlative values of the experiment. The pick count included both secondary and primary pickout spots larger than the approximate size of a typed period. This gives a count that is representative of the picking accrued to that point. The "number of pickouts" count was chosen over an "area of pickouts" which represents the total area of non-printing pickout spots and is expressed in square millimeters. The size of the individual pickouts has a bearing on the value attached to the test.

LITERATURE CITED

49 Albert T. Kuehn, "True Rolling and Packing on Offset Presses," (Chicago, Illinois, The Miehle Company, 1956) p. 2.

50 Ronald C. Reph, 3-M Company (letter to the author, September 18, 1967).

51 Raymond J. Prince, GATF (letter to the author, November 11, 1967).

CHAPTER III

FINDINGS

Extremely relevent to the final results was the lack of picking to the degree that significant variations were apparent. The paper did not pick to the extreme necessary to have been rejected according to quality control standards of Westvaco. The difference in picking results between the mill's quality control test and the author's experiment could have been a result of a number of variations, including paper surface changes, press changes, ink differences, and atmospheric differences. Jacqueline M. Fetsko of the National Printing Ink Research Institute states, "All printing conditions affect picking results to some extent. Since conditions from one press to another can rarely be duplicated, it is impossible to expect exactly the same picking performance of an ink-paper combination on different presses."[52] With paper itself being an extreme variable, the reproducibility of picking results under offset press testing conditions has not been proven to be extremely high. Even with samples of paper from a single roll "the exact reproducibility of print count results is very slight."[53] One possible reason for testing differences is that this particular paper is coated with a calcium carbonate pigmented coating with a latex base vehicle. This type of coating tends to stabilize with age, often resulting in improved coating bond to the base stock. Another difference in testing procedures that probably had a bearing on the difference in picking results between quality control testing and the results obtained in the author's experiment was atmospheric conditions. Quality control conditions at Westvaco's mill are maintained at approximately 75° Fahrenheit and 50 per cent relative humidity. Thus the atmospheric conditions for this experiment were approximately 5° Fahrenheit lower and the relative humidity was 18 per cent lower than mill conditions. This lower humidity in the pressroom would result in a low moisture content in the paper. Because of the paper's hygroscopic properties it would be very receptive to any excess water on the blanket. This in turn would result in less water available to be emulsified with the ink.

Also, although the blanket proved to be dimensionally stable because of its solvent repellent coating, this resulted in a smooth, quick-release surface that would tend to lessen the absorption of the ink vehicle into the blanket. This in turn, would have lessened the force required to split the ink film during the ink transfer process. Westvaco does not use this type blanket.

Other variables, such as the amount of printing pressure, the ink film thickness, etc. could also have caused differences in pick count results from mill findings and those of the experiment.

Printing impression, an important variable affecting picking, was at a minimum. In setting up the press, the blanket and impression cylinders were separated until there was insufficient printing pressure. The cylinders were then closed up in one thousandth inch increments until an acceptable ink transfer was achieved. With a solid such as the one printed on the test sheets, approximately .004 inch impression was necessary.

The plate was packed to .007 inch above the cylinder bearers. The blanket was packed to .0025 inch below the cylinder bearers. This resulted in .0045 inch impression between the plate and blanket. With .004 inch impression recommended by the press manufacturer, this was considered sufficiently close.

The temperature at the beginning of the experiment was 70° Fahrenheit.

The relative humidity at the beginning of the experiment was 33 per cent.

The fountain solution pH at the beginning of the experiment was 4.0.

The ink and water form rollers were set for proper contact with the printing plate before the experiment and there were no changes made during experimentation.

Unrandomized samples were printed to determine the correct amount of water needed for a balance with the established amount of ink. A fountain setting of five resulted in a proper ink and water balance. This was established by visual appearance of the sheets printed. Another unrandomized sample was printed to determine the fountain setting which resulted in scumming of the plate. This point was established as three. Following is a sample-by-sample account of the findings during the experimentation.

The Experiment

Sample Number One

The press was run for ten minutes without the ink or water turned on to allow evaporation of the water that had emulsified with the ink. The plate and blanket were washed free of ink and lint particles. The water fountain was set at three, the fountain roller was turned four times, and three-hundred sheets were printed.

There were no press stops during the test.

The plate scummed more on the drive side than the operator's side. This was not uncommon for this press, according to the operator. The fountain rollers were checked again, but no discrepancies were found, so the experiment proceeded without a change in the roller settings. Many presses have a tendency to run drier on the drive side because of the heat generated by the gears. This may have been the case here.

Picking was noticed throughout the press run, however, it wasn't considered profuse enough to be conclusive. At this point the decision was made to print the other side of the sheet on subsequent runs to obtain a more profuse picking situation.

A packing check, upon completion of the test, showed the plate, plus .007 inch; the blanket, minus .0025 inch in relation to their respective bearers.

The results of this sample were not figured with subsequent samples because of the difference in the printing surfaces.

Sample Number Two

The press was run ten minutes with the ink and water off.

The plate and blanket were washed. The water fountain was set at three, four turns of the fountain roller were made, and three-hundred sheets were printed. This sample and all subsequent samples were printed on the opposite side of the sheet as was the case with sample number one.

The print scummed badly early in the run, began to scum less between fifty and two-hundred impressions, after which time the scumming remained static. This indicated that an insufficient amount of water was used in starting up the sample run. Again scumming was worse on the gear side of the press. This sample as well as the following samples did not pick to the desired extreme.

A pH check of the fountain solution showed approximately 4.0.

Temperature--70° Fahrenheit.

Relative Humidity--32 per cent.

A packing check showed the plate--plus .007 inch in relation to the cylinder bearers; blanket--minus .0025 inch in relation to the cylinder bearers.

Sample Number Three

The press was run ten minutes with the ink and water off.

The plate and blanket were washed.

The fountain was set on four, four turns of the water fountain roller were made, and three-hundred sheets were printed. There were no press stops.

Scumming occurred consistently throughout the press run.

A packing check showed the plate--plus .007 inch; the blanket--minus .0025 inch in relation to their cylinder bearers.

Picking throughout the run did not appear to be excessive.

Sample Number Four

The press was run ten minutes with the ink and water off.

The plate and blanket were washed.

The water fountain was set at five, the fountain roller was turned four times, and three-hundred sheets were printed. There were no press stops.

Scumming occurred slightly at the beginning of the press run, but began to clear up after approximately 200 sheets were printed. This indicated that the press was near optimum ink and water balance.

Because there had been no change in the packing to this point, the packing was not checked.

Picking throughout the run did not appear to be excessive.

Sample Number Five

The press was run ten minutes with the ink and water off.

The plate and blanket were washed.

The water fountain was set at six, the fountain roller turned four times and 299 sheets were printed. The feeder stopped after fifteen impressions, the press was restarted, with one sheet passing through without being impressed. This did not seem to affect the final result. Picking did not appear to be excessive throughout the run.

The ink and water were balanced well.

The packing was not checked.

Sample Number Six

The press was run ten minutes with the ink and water off.

The plate and blanket were washed.

The water fountain was set at seven, the fountain roller turned four times, and three-hundred sheets were printed. There were no press stops. Picking appeared to be consistently slight throughout the run.

The ink and water appeared to be in balance.

There was no packing check made.

Sample Number Seven

The press was run ten minutes with the ink and water off.

The plate and blanket were washed.

The water fountain was set at eight, the fountain roller turned four times and 295 sheets were printed. There were three press stops; after 139 impressions, 223 impressions, and 260 impressions. Five sheets passed through the press without being printed. According to the pick count, these stops did not affect the results. Picking still appeared to be consistent with previous tests.

The ink and water balance was visually acceptable.

A packing check showed the plate--plus .007 inch; blanket--minus .0025 inch, no change from the previous checks.

Sample Number Eight

The press was run ten minutes with the ink and water off.

The plate and blanket were washed.

The water fountain was set at nine, the fountain roller turned four times, and three-hundred sheets were printed. There were no press stops. Picking throughout the run still appeared to be consistent with previous tests.

The ink and water appeared to be balanced.

There was no packing check made.

Sample Number Nine

The press was run ten minutes with the ink and water off.

The plate and blanket were washed.

The water fountain was set at ten, the fountain roller turned four times, and three-hundred sheets were printed. There were no press stops.

At this point the ink and water balance changed slightly to the point where the effects of the water were visible on the printed sheet. Slight water roller streaks appeared in the solid, especially at the trailing edge of the sheet. These streaks tended to disappear as the ink set. There was still no apparent change in the degree of picking during the press run.

There was no packing check made.

Sample Number Ten

The press was run ten minutes with the ink and water off.

The plate and blanket were washed.

The water fountain was set at eleven, the fountain roller turned four times, and three-hundred sheets were printed. There were no press stops. Again, picking throughout the press run appeared to be consistent with the previous tests.

At this water setting, the water form roller bounce showed a noticeable streak running horizontally at the top edge of the solid. The trailing edge of the solid was slightly washed out, showing water streaks running vertically. Also, the halftones, especially the one with the greatest amount of highlight areas, took on a noticeable snowflakiness. All of these signs are indicative of an excess of fountain solution.

A pH check of the fountain solution showed approximately 4.0, which was the same as recorded at the beginning of the experiment.

A packing check showed the plate--plus .007 inch; blanket--minus .0025 inch, no change from the original and subsequent checks.

This concluded the experiment; beyond this point printing quality would suffer noticeably as a result of the excessive amount of water.

Picking Analysis Procedure

Using the printed solid as a counting area, all the pickout spots (primary and secondary) larger than approximately the size of a typed period were counted. By counting both the primary and secondary pickouts a figure representative of the total picking that occurred throughout the run was obtained. The 200th, 250th, 300th, and 150th printed sheets of each sample were counted and the value attached to each run was the average of these four sheets.

A "number of pickouts" count rather than an "area of pickouts" count was used so that every pickout would have the same value. This eliminated the possibility of one large pickout or a great many small pickouts throwing off the correlative values.

This method of quantitatively evaluating picking is a combination of the methods used by Westvaco and Company X.

TABLE I

Picking Analysis Results

Pick Counts (Every preceding fiftieth sheet was counted from the last printed sheet on samples that did not have 300 impressions.)

Sample Number	Fountain Setting	300	250	200	150	Total	Mean
2	3	13	15	15	9	52	13
3	4	3	8	7	6	24	6
4	5	10	8	7	6	31	7.7
5	6	9	9	12	10	40	10
6	7	7	6	7	8	28	7
7	8	15	13	6	6	40	10
8	9	7	9	3	6	25	6.2
9	10	6	4	6	5	21	5.2
10	11	12	8	5	5	30	7.5

Sample one is not represented in the above table because it was printed on the opposite side of the sheet.

Sample two had the highest average pick count, 13. This was also the sample printed with the least amount of fountain solution. The quantitative pick analysis does not show the expected gradual increase in pickout spots. Often a pick count early in the run is equal to or greater than a count at the end of the run.

Sample three was also printed with an insufficient amount of fountain solution (a fountain setting of four) and recorded next to the lowest average pick count of all the tests.

Sample four showed a progressive increase in pick counts from the 150th to the 300th sheet. The water fountain was set at five and approached a proper ink and water balance.

Sample five, printed with a water fountain setting of six, had a visually acceptable ink and water balance. This resulted in a mean pick count of 10, which was the second highest score of all the tests.

Sample six also printed with a visually acceptable ink and water balance. Its mean pick count was three less than the previous sample.

Sample seven printed with a visually acceptable ink and water balance. Its pick count was the same as sample five.

Sample eight was printed with a visually acceptable ink and water balance with a fountain setting of nine. The mean pick count decreased from ten of the previous sample to 6.2.

Sample nine was printed with a water fountain setting of ten. This sample showed the first traces of an excessive amount of fountain solution. It also recorded the lowest average pick count of 5.2.

Sample ten was printed with the water fountain set at eleven. The excessive amount of fountain solution was readily apparent in water streaks in the solid and snowflakiness of the halftones. These effects were made less apparent as the ink lost its gloss as a result of drying. The mean pick count was 7.5, which was an increase of 2.3 over the previous sample.

LITERATURE CITED

52 Jacqueline M. Fetsko, "Sources of Differences in Picking Results Among Presses," (Bethlehem, Pennsylvania, National Printing Ink Research Institute Bulletin 60, 1962) p. 1.

53 Roger L. Williams, "Correlative Accuracy of Offset Print Testing Procedure at Westvaco's Mechanicville, Tyrone, and Luke Mills," (Tyrone, Pennsylvania, Westvaco Quality Control Report, 1966) p. 11.

CHAPTER IV

CONCLUSION

Through the linear correlation method of statistical analysis, the correlative relationship of the amount of fountain solution used on a single unit sheet-fed offset press and the degree of picking encountered under the particular conditions of this experiment were established at a correlation coefficient (r) of minus .50. This figure represents a point on a scale that ranges from negative 1.0 (perfect inverse correlation) to a positive 1.0 (perfect positive correlation). The center being 0.0 (absolutely no correlation). Therefore, the correlation established for this experiment is in the inverse direction, but is not significant to the .05 level of significance. Hence, the author accepts the null hypothesis and considers the correlation insignificant to a confidence level deemed necessary to be useful in industry. The mathematical computations for determining the correlation coefficient (r) and the level of significance may be found in Appendix D.

The randomness of the points plotted on the following graph also illustrates the lack of correlation. Perfect correlation expressed linearly would result in the points being plotted in a straight line. The degree of randomness is shown by the variations of the distances of the points from the line approximately representing the correlative trend.

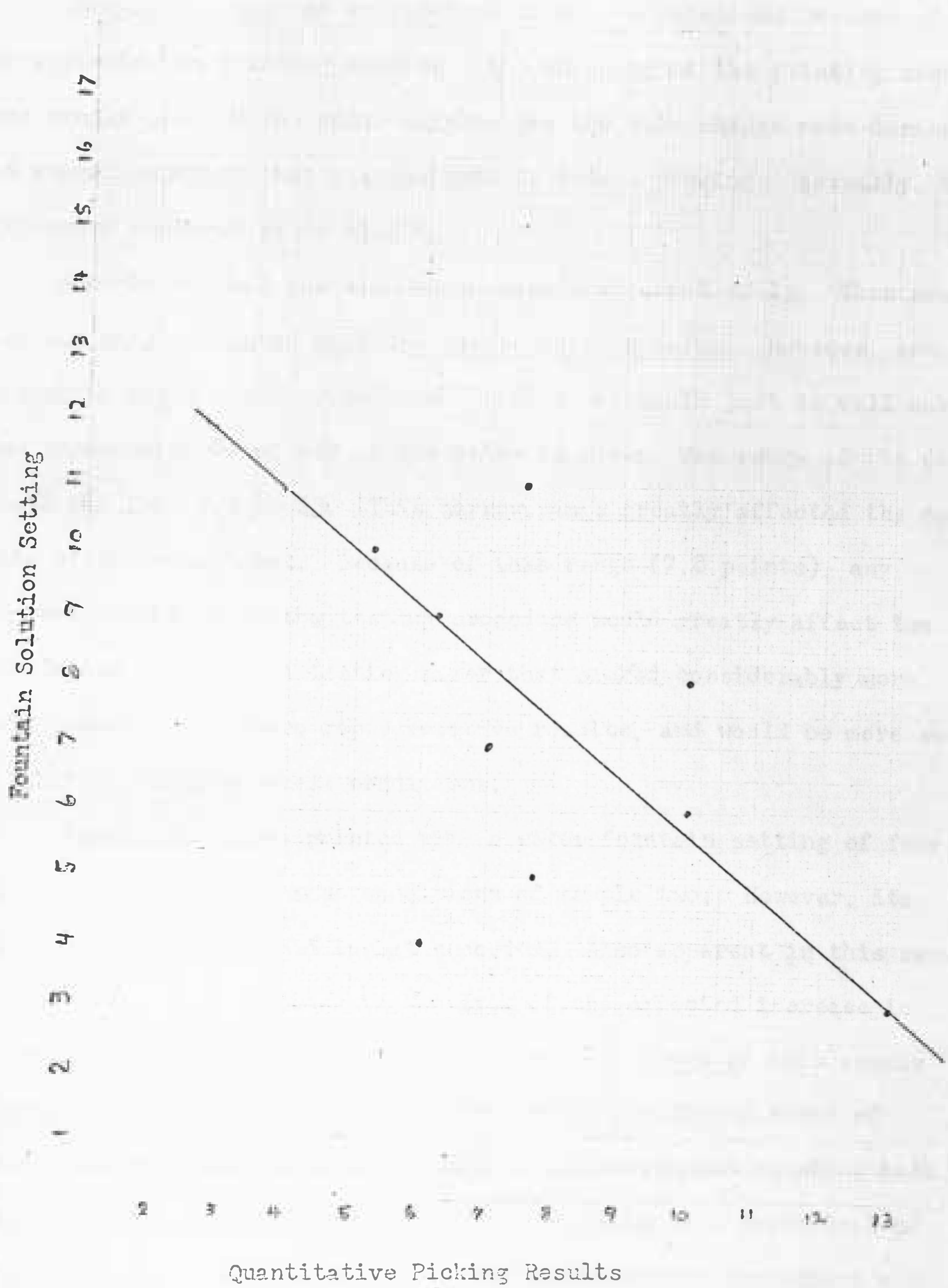

FIGURE 3

Graphic Illustration of Picking Analysis Results

Sample one was not represented in any computations because of the variation in printing surface. The changing of the printing sides from sample one and the other samples was the only change made during the experimentation that was designed to induce picking. Actually, the difference appeared to be slight.

Sample two had the highest average pick count of 13. This was also the sample printed with the lowest water setting. However, according to the overall correlation, this score could just as well have been representative of any of the other samples. The range of the pick counts was from 5.2 to 13. This narrow range greatly affected the results of the experiment. Because of this range (7.8 points), any inherent variation in the testing procedure would greatly affect the correlative results. A testing paper that picked considerably more would probably give more representative results, and would be more susceptible to changing press conditions.

Sample three was printed with a water fountain setting of four, which is very near the same conditions of sample two. However, its pick count was the second lowest recorded. Also apparent in this sample, as with other samples, is the lack of the expected increase in pickout spots as the run progresses. The 150th sheet of this sample recorded a pick count of six; the 300th sheet recorded a count of three, just the opposite of what would be expected when counting both primary and secondary pickouts. There appears to be a great deal of variation in the picking present on individual sheets throughout a press run. The pick count is not necessarily dependent on a buildup of secondary pickouts. This phenomenon is largely a result of the self cleaning characteristics of an offset press which results from the inking system's ability to remove debris from the printing plate and transfer it to the top rollers of the ink train. Ordinarily, there is a constant removal of particles from the plate that is counteracting the deposit of particles from the paper to the blanket and plate. In the author's opinion, the times when picking spots gradually increase, are when fibers, vessel segments, scale, coating, etc. are being removed from the paper faster than they are being removed from the plate. Because of the lack of a buildup of pickouts from the beginning to the end of most samples. there was apparently almost a balance between the amount of debris being deposited and the amount being removed. This was represented by the fact that six of the nine samples had a pick count on the 300th sheet equal to or less than counts on previous sheets of the same sample.

Sample four, printed with the water fountain set at five, resulted in a mean pick count of 7.7. This sample recorded a gradual increase of pick counts from the 150th sheet (6) to the 300th sheet (10). This was not the usual case and probably is the result of a chance happening rather than a causal occurrence.

Sample five was printed with a water fountain setting of six. This sample recorded a lower pick count on the 300th sheet (9), than on the 150th sheet (10). The ink and water were balanced well with this sample. The mean pick count 10 was second highest of all the samples printed.

Sample six was printed with the water fountain set at seven. This fountain setting resulted in a visually acceptable ink and water balance. The mean pick count was seven and there was very little variation in picking from the beginning of the run to the end. This indicated an early balance between the rate of picking and the rate of removal of particles from the plate.

Sample seven was printed with a water fountain setting of eight, and resulted in a mean pick count of ten. This sample showed a radical increase in picking from the 200th sheet printed (6) to the 300th sheet printed (15). This increase in count may have been caused by paper variations at the end of the run and/or inherent variations in the test or counting procedures.

Sample eight was printed with a water fountain setting of nine, and resulted in an average pick count of 6.2, which was the third lowest recorded. The ink and water balance was still visually acceptable.

Sample nine was printed with a water fountain setting of ten. This sample showed the first traces of an excessive amount of water. This was also the sample with the lowest mean pick count, 5.2. There was very little picking recorded throughout the run, which indicated an early balance between the addition and extraction of foreign particles to and from the blanket and plate.

Sample ten was printed with a water fountain setting of eleven. This sample showed the greatest effects of the water's emulsification with the ink. The horizontal water streak at the top of the solid is caused by the bump of the water form roller as it comes out of the cylinder gap, and onto the plate. The faint vertical streaks at the bottom of the solid are caused by the rolling of most of the excess water to the trailing edge of the plate. The snowflakiness of the halftones is caused by some of the dots losing their affinity for ink, thus not printing. This sample recorded the fifth highest mean pick count, 7.5.

As mentioned on page 34, the tack of the ink used in the experiment was found to be very stable with the addition of water. Consequently, there would be little decrease in the tack of the ink with the emulsification of fountain solution. Therefore, the degree of change in picking from one extreme of water to the other would also be slight. With a less stable ink, perhaps a more significant correlation may have been found.

In summary, two conclusions may be drawn from this experiment. First, the correlation coefficient (r = negative .50) did not reach the .05 level of significance, therefore the null hypothesis was accepted under these particular testing conditions. Under a different set of variables, perhaps a different conclusion may have been drawn. And, secondly, instead of a gradual increase in the effects of picking, there seemed to be no relationship between the pick count obtained at one point in a press run and the count obtained at another point.

Recommendations for Future Study

The subject encompassing the area of ink transfer is a highly nebulus one which pleads for a great deal of research.

All of the specific areas that show promise for future research are too numerous to mention in this thesis. However, a few will be mentioned to exemplify the intense need for study on the subject of offset printing. These areas will be suggested in the form of questions, allowing the reader to delve into his own intellectual reservoir for procedural answers.

What part does the fountain solution play in the ink transfer process from the blanket to the paper? What exactly are the variables that affect the efficiency of the ink transfer process? How can these variables be isolated? How can they be analyzed?

Of all the inherent variables in the offset ink transfer process, which ones affect the propensity of a sheet of paper to pick? How are these variables related to picking? How can they be controlled?

What is the most important variable in the paper-tack-picking interaction? Of the variables affecting picking, which ones can be controlled by the pressman? What can the pressman do to alleviate the problem of picking without losing quality in other areas?

These are only a few questions that need answering. There are many, many more.

APPENDIX A

Following is the letter that was sent to printing ink manufacturers and researchers in order to accumulate information relevent to the thesis topic. Along with the letter are copies of some of the more informative replies.

Dear Sir:

I am a graduate student in printing management and will be soon writing a thesis on the problem of picking on sheet-fed, coated, offset paper. As part of the research for my thesis I intend to run an experiment to determine the relationship between the amount of fountain solution used and the degree of picking encountered. The experiment will consist of a series of press runs with all press settings constant and varying the fountain solution. A quantitative pick analysis will be made at the end of each run to determine if a correlation exists.

Any information or sources of information on the following would be greatly appreciated:

1. What is ink tack and how is it related to picking?
2. How is the ink tack affected by the amount of water used in the printing process?
3. How is the ink tack affected by the pH of the fountain solution or various components such as etch and gum?
4. What other characteristics of printing ink have a bearing on the degree of picking encountered?

I would also be grateful for any suggestions or other information. Thank you for your consideration.

Very truly,

Roger L. Williams

Sun Chemical Corporation
Graphic Arts Laboratories
631 Central Avenue
Carlstadt, New Jersey
September 27, 1967

Mr. Roger L. Williams
South Dakota State University
Printing Laboratory, College of
Arts and Science
Brookings, South Dakota 57006

Dear Sir:

Your letter of September 21st is an invitation to write a book.

The problem of coating pick in sheet-fed offset printing is rather simple where single color work is being done and picking only in printed areas takes place. It can be stated in two ways, each of which implies its particular solution.

1. The paper lacks sufficient pick resistance for use with the ink, printing form and press speed demanded. Use stronger paper.

2. The ink is too high in viscosity for the specific job, press speed, and paper under consideration. Use a lower viscosity (softer, less "tacky") ink.

Ordinarily, in single color work there is little or no correlation between the quantity of water picked up by the ink and picking. This is due to the fact that such water exists as the internal phase of a water/oil emulsion. As such it increases the shortness of the ink but has little effect on its plastic viscosity, and within permissible range of water take-up has little effect on picking.

If you start your series with a paper and ink combination that will cause no picking at any ink film thickness or any press speed, it is a reasonable assumption that you'll experience no picking in the range of from starved to flooded water settings. There have been so-called cases of this type, but the few I have seen involved ink-paper combinations that were borderline. Close analysis showed that increasing press speed and/or decreasing ink film thickness would result in picking. In such cases the shortening of ink that is likely with water take-up can push the system just over the edge and picking will occur. Other factors could cause the same results and the contribution made by water would be difficult to assay.

As suggested above, the situation is relatively simple for single color printing. On multi-color presses the water applied to nonprinting areas on the first impression can soften a sensitive coating so that its resistance to picking is seriously reduced. This effect can become virtually a geometric progression on 4 or 5 color presses so that picking occurs on printing as well as nonprinting areas as the sequence progresses. I have seen several cases where the build up of coating clay on nonprinting areas of the 4th down blanket became so thick that the printing areas could not contact the sheet.

Certainly, nothing that could be done with the ink-water balance on the 4th unit could have been beneficial. These few cases were on web offset presses where, because of economic considerations, efforts were being made to use letterpress coated stock. These pioneering efforts failed, but paper manufacturers have improved the water resistance of some of their letterpress papers to a point that permits their use on multi-color offset presses.

The subject of picking has been studied by Graphic Arts Technical Foundation in Pittsburgh, Pa., and by National Printing Ink Research Institute in Lehigh University, Bethlehem, Pa.

You might write Mike Bruno of G.A.T.F., and Dr. A.C. Zettlemoyer of N.P.I.R.I., who should be able to supply reports or at least bibliographies of interest. Of course, others like PATRA in England, FOGRA in Germany, and Swedish as well as Dutch Graphic Arts Research Groups, have explored this field. Their work has been reported in numerous journals.

It would be useful if pick resistance could be measured and stated in some significant term. Using a standard ink at standard film thickness and a press capable of operation over a wide speed range, paper can be rated in terms of feet per minute at which they will pick.

Using a constant speed printer and a series of tack graded inks, a paper can be rated in terms of the number of the tackiest ink it will tolerate under the conditions of test.

Neither method correlates well with press experience. A serious problem is paper sampling. In a given mill run several tens of square miles may be produced. It varies rather widely from edge to edge on the paper machine, from place to place in the roll, and from roll to roll. Samples to be investigated are measured in square inches. What is the probability of their being representative?

1. Essentially, tack is the resistance to splitting offered by ink films. Work is required to overcome this resistance. If an infinite period of time in which to split a film of unit area is provided, the energy input during any instant is exceedingly small and even a weak paper will not pick. On the other hand, if the same film were to be split in an infinitely short time interval, the energy requirement would approach an exceedingly high level and even the most rugged of papers would be ruptured.

2. As suggested earlier, the amount of water normally used in the offset process has but limited effect on tack.

3. Unless something is woefully wrong with the ink pH, type of acid or gum in normal concentration have little, if any, effect on ink tack.

4. Its rheological properties primarily determine an ink's tack. These are determined by the chemical and physical properties of the vehicle; by the physical, chemical and colloidal properties of the pigments and extenders used, and the relative proportions of liquids to solids present. We have wide latitude in compounding inks with appropriate tack to suit virtually any printing process and substrate.

Scumming, blinding, mottling, piling, non-drying, and other deficiencies can be built into an ink by injudicious selection of its components. Picking is not in this class. It is always the result of an inappropriate choice of ink or paper.

I am somewhat interested in how you will make your ink selection for the thesis work. Some inks, such as those based on high melting phenolics, cyclicised rubber or petroleum resins, pick up only six or eight per cent of water. Straight linseed and some long oil alkyds can pick up 20 to 25 per cent of water and continue to print normally. Which will yield the most information? I don't know nor can I suggest an "average" ink. It doesn't exist anymore than the average student, average wife, or what have you.

Your project interests me because 33 of my 43 years in the ink industry have been spent in research and development. A major deterrent to progress in studies such as you propose is associated with that premise "with all press settings constant." A press is a machine, not an instrument. The only thing constant about it is its inconstancy.

Assume that you pack your blanket cylinder to optimum height. This determines the nip pressure between paper and blanket. If the packing compresses with use, in a few hours this pressure will drop, the dwell period will decrease, the separation forces increase, and if conditions are borderline, picking might show up. Neither ink nor paper have changed. The results can be confusing.

If the packing picks up moisture either because of a rise in humidity or because of fountain solution seeping into the edges of the paper, an opposite effect can be expected.

Of perhaps more importance is changes in ink film thickness due to inherent inadequate control of the fountain or to temperature changes due to ambient conditions and to the work being done on the surface of the ink distributing roller system. A 1°C rise in the temperature of an ink causes a nine per cent drop in its viscosity. Many who have made a study of ink rheology believe that tack and viscosity are closely related, if not synonymous.

An ink having a viscosity of 100 poises at 32°C will drop to 58 poises at 38°. This represents something approaching a 50 per cent drop in tack, so the influence of temperature on picking is quite obvious.

Picking is always a function of film thicknesses being applied. For any given ink-paper combination, the curve of pick plotted against film thickness goes through a maximum that is at a thickness just a little below the normal level required. Since no pressman can set a foundation so accurately that ink film remains constant, it varies up and down throughout the run and frequently gets into the range of maximum pick. This too if not recognized can obscure results.

What disturbs me is the feeling that this research project has been based on two premises which are somewhat less than true. One is that picking is somehow a property of a printing ink, and the other that this can be significantly affected by the quantity of water used, its pH, or other factors.

Under these conditions, the probability that this research will be fruitful seems vanishingly small.

This rather negative evaluation was inspired by your request for "suggestions or other information." I would be remiss if I did not present the facts as they are known to me. The Graphic Arts in all its phases urgently needs competent research. It is a highly complex area at best loaded with pitfalls. It would be highly desirable to put the time and effort into a project that offered a better opportunity for meaningful results.

Sincerely yours,

Jos. G. Curado
Research Director

JGC:bw

Sinclair and Valentine Company
Research Laboratories
611 West 129th Street
New York, New York 10027
October 6, 1967

Mr. Roger L. Williams
South Dakota State University
College of Arts and Science
Brookings, South Dakota 57006

Dear Mr. Williams:

I will try to answer the four questions posed in your (circular) letter of September 21, 1967. By necessity my answers will be very short because - as you must know by now - many books and papers have already been written about the subject of your questions. Furthermore, some of your questions concern problems which are not yet fully understood and continue to be in intense study.

One institution heavily engaged in studying the subject area of your question is the National Printing Ink Research Institute, at Lehigh University, in Bethlehem, Pa.; Dr. Zettlemoyer is the Director of Research there.

I do not intend to give you a lengthy bibliography, but two books are "a must" for you if you are really interested in "tack", namely:

Andries Voet. Ink and Paper in the Printing Process. Interscience, New York - 1952.

E. A. Apps. Ink Technology for Printers and Students. Leonard Hill, London, 1963. 3 vol. (there are later editions also).

Now, then, here are my brief answers:

1) One good definition: "Tack is the resistance offered by ink films during splitting. Voet describes "Picking under actual printing conditions (as) a complicated phenomenon, strongly influenced by paper, ink, plate, press and speed of printing."

For many years printers and ink masters believed to understand the nature of tack quite well. This belief was based on the "Stefan" equation (1874) which states:

$$F = \frac{3\ Z\ O}{4\ t\ h^2}$$

F = Force necessary to separate two inked plates.

Z = Viscosity (in poises) of ink between the plates.

O = Plate area.

t = Time of separation (= printing speed).

h = Distance of plates (= film thickness).

This equation is self-explanatory, simple and easy to understand.

From about 1950 on, however, serious thinkers, especially Voet, questioned the full applicability of this equation to actual printing conditions (especially at higher printing speeds).

It was found that at low printing speeds (my guess up to about 300 ft./min.) the Stefan equation holds pretty true and certainly predominates the splitting behavior. However, at higher printing speeds another regime takes over. At these speeds liquids start behaving like "elastic solids." At the present time several institutes of higher learning are intensely studying these regimes, but the nature of the "elastic component" of printing inks is not yet fully understood. As a matter of fact, we speak today of the visco-elastic properties of inks.

The relationship of ink to picking is complex as stated by Voet; in a simplified way we might say that picking will occur when (under the existing conditions) the joint forces of ink adhesion and cohesion are greater than adhesion or cohesion of the paper surface. You will find a much better explanation in Voet - page 154: "Paper rupture in the printing process must be considered to occur when the energy density of the impacting wave exceeds the rupture energy density of the paper" (an elegant experiment is described on page 153).

2) In most cases water emulsified into the ink will reduce the tack properties of the ink.

3) Influence of fountain pH on tack properties of ink was not yet fully investigated - to the best of my knowledge.

4) I recommend careful study of Voet's book, especially Chapter XIV.

Good luck.

Sincerely,

SINCLAIR AND VALENTINE

Carl B. Blake
Director of Research

CBB:ra

APPENDIX B

Following is the letter sent to the manufacturers of coated offset paper in order to accumulate information relevent to the thesis topic. Along with the letter are copies of some of the more informative replies.

Dear Sir:

I am a graduate student in printing management and will be soon writing a thesis on picking on sheet-fed coated offset paper. The thesis will cover the causes, remedies, and classifications of picking. Also I will be conducting an experiment to determine the relationship between picking and the amount of fountain solution used.

I would appreciate any information or sources of information that you could give me on the following:

1. What method do you use to quantitatively analyze coated sheet-fed offset paper for picking properties?

2. What research have you done in the area of classifying original pickouts such as vessel segments and where can I get samples or microphotographs of the same?

3. What are some of the causes and remedies for picking on sheet-fed coated offset paper?

4. What is the relationship of the fountain solution to the tack of the ink?

I would like to visit your mill during the first week of October to gather information in person. If this is suitable to you, please let me know.

Sincerely,

Roger L. Williams

Paul J. Hopkins
The Northwest Paper Company
Brainerd, Minnesota
September 26, 1967

Dear Mr. Williams,

Listed below are some of the tests that would be related to picking. Some of these are used for quality control wheras others are used as a research tool: IGT, S.D. Warren MP Pick, wax pick, and Scott Internal Bond. Also an ATF Chief 24 Offset Press is used to check the quality of our finished sheet.

We have not classified pick-outs as being vessel elements or fibers, but photomicrographs are available in a book entitled "382 Photomicrographs of 91 Paper Making Fibers" by C. H. Carpenter, and L. Leney, State University of New York College of Forestry at Syracuse.

Some of the causes of picking would be insufficient adhesive in the coating formulation, or improper distribution of the coating adhesive in the Z direction of the paper, high internal ash content, too much broke (reclaimed fiber) in the pulp furnish, low wet strength, high ink tack, and fast press speeds.

Before a new grade of paper is placed on the market extensive press testing in the field is undertaken using the most difficult form that this grade would be likely to encounter.

The relationship between the amount of fountain solution used, ink tack, and picking is not black or white, but dependent upon the degree of each variable. The more fountain solution used, the greater the tendency of the water to emulsify in the ink causing the tack to decrease which by itself would produce a lower picking tendency. However, when more fountain solution is used a damper sheet would result given a weaker surface on a multicolor press. In conclusion the tendency of the sheet to pick would be dependent upon the resistance of the ink to emulsify the water and the water resistance of the sheet.

Some of the articles listed below contain references that will be of further value:

Pulp & Paper Mag. Canada 68, No. 4, 110-112; April, 1967.

Casey, Pulp & Paper, Vol. III, 1689, 1798, & 1838-39.

"What The Lithographer Should Know About Paper," Technical Bulletin No. 8, Lithographic Technical Foundation, Inc.; pp. 29-30, 67, 129.

Hsu, Baysung, "Tack Stress and The Picking Resistance of Paper." Tappi, July, 1963; page 438.

We would be most pleased to have you visit the Brainerd Mill.

Sincerely,

Paul J. Hopkins

APPENDIX C

Following are three samples of the actual printed sheets obtained from the experiment. These samples were taken at the end of their representative runs and are indicative of the picking and press conditions of their individual tests.

The first sample is representative of the beginning of the experiment when the water setting was on three and there was excessive scumming. Note the filled-in areas of the halftones, particularly the girl's picture which was on the drive side of the press.

The second sample is representative of a visually acceptable ink and water balance. The water fountain setting for this print was six. Note the sharpness of the halftones; the definition of the star targets, fill-in scales, and quality control strip. Also, notice the smooth, even lay of ink in the solid area.

The third sample is representative of the last press run of the experiment. In this case, the fountain solution is excessively out of balance with the ink. Note the snowflakiness and dampener form roller streaks.

Looking at the three prints together gives one a representative idea of the extent of picking encountered throughout the experiment.

0123456789

0123456789

APPENDIX D

Following is the method of statistical analysis used to determine the correlation between the water fountain setting and the pick count. The statistical method used is the correlation coefficient which provides a quantitative measurement of the relationship between two variables.

Fountain Setting	Pick Count	Mean Dev. Fountain	Mean Dev. Picking	X^2	Y^2	XY
3	13	-4	4.9	16	24.01	-19.6
4	6	-3	-2.1	9	4.41	6.3
5	7.7	-2	-0.4	4	.16	.8
6	10	-1	1.9	1	3.61	- 1.9
7	7	0	-1.1	0	1.21	0.0
8	10	1	1.9	1	3.61	1.9
9	6.2	2	-1.9	4	3.61	- 3.8
10	5.2	3	-2.9	9	8.41	- 8.7
11	7.5	4	-0.6	16	.36	- 2.4
				60	49.39	-27.4

Correlation coefficient (r)

$$r = \frac{XY}{\sqrt{\Sigma X^2 \cdot \Sigma Y^2}}$$

$$r = \frac{-27.4}{\sqrt{60 \cdot 49.4}}$$

$$r = -.50$$

Levels of Significance

degrees of freedom = N-2

N = Number of XY pairs

(df) = 9-2 = 7

(r) necessary for significance levels

(df)	.05	.01
7	.67	.80

The correlation coefficient (r) = -.50 is not sufficient for a .05 level of significance.

APPENDIX E

The method of randomizing the paper for the experiment was as follows:

1. Three thousand sheets were separated into lifts of fifty sheets apiece. Each lift of fifty was numbered consecutively from the top of the skid to the bottom. This resulted in sixty individual lifts.

2. The number seven was picked randomly as a number between one and ten.

3. Using seven as a starting point, every seventh lift was numbered consecutively until every lift was assigned a number.

4. Each individual press run contained six lifts. Following is a breakdown of the lifts that comprised each of the ten press runs:

Press Test	Lift Numbers
1	43, 26, 9, 52, 35, 18
2	1, 44, 27, 10, 53, 36
3	19, 2, 45, 28, 11, 54
4	37, 20, 3, 46, 29, 12
5	55, 38, 21, 4, 47, 30
6	13, 56, 39, 22, 5, 48
7	31 14, 57, 40, 23, 6
8	49, 32, 15, 58, 41, 24
9	7, 50, 33, 16, 59, 42
10	25, 8 51, 34, 17, 60

BIBLIOGRAPHY

Books

Anonymous. Printing Ink Handbook, 1st Ed. (New York, National Association of Printing Ink Makers, 1958).

Anonymous. Printing Ink Handbook, 2nd Ed. (New York, National Association of Printing Ink Makers, 1967).

Apps, E. A. Ink Technology for Printers and Students, (London, Leonard Hill, 1963).

Hartsuch, Paul J. Chemistry of Lithography, (New York, Lithographic Technical Foundation, 1961).

Larsen, Louis M. Industrial Printing Inks, (New York, Reinhold Publishing Corporation, 1962).

Latham, Charles W. Advanced Pressmanship, (New York, Lithographic Technical Foundation, 1963).

________. Lithographic Offset Press Operating, (New York, Lithographic Technical Foundation, 1960).

MacDonald, David J. Offset Press Troubles, (New York, Lithographic Technical Foundation, 1944).

Reed, Robert F. Web Offset Press Troubles, (Pittsburgh, Graphic Arts Technical Foundation, 1966).

________. What the Lithographer Should Know About Ink, (New York, Lithographic Technical Foundation, 1960).

Voet, Andries. Ink and Paper in the Printing Process, (New York, Interscience, 1952).

Articles and Periodicals

Anonymous. "Canadian Printer and Publisher Troubleshooting Chart," Canadian Printer and Publisher, p. 32-49 (December, 1965).

Anonymous. "Runnability and Printability in Papers," Inland Printer/American Lithographer, p. 61-63, 132-133 (October, 1967).

Bureau, William H. "Coated Papers for Lithography, Part 1," Graphic Arts Monthly, p. 86-88 (September, 1958).

_______. "Coated Papers for Lithography, Part 2," Graphic Arts Monthly, p. 102-104 (October, 1958).

_______. "Hickies and Spots," Graphic Arts Monthly, p. 42, 44, 160, 162 (June, 1959).

_______. "Major Differences Between Web and Sheet Offset Papers," Graphic Arts Monthly, p. 92, 94, 96 (May, 1965).

Burtt, Richard F. "What Affects the Acceptability of Offset Printing Papers," Paper Trade Journal, p. 40-43 (August 14, 1967).

Diehl, Oscar. "How Offset Lithographers Can Avoid Hickies," Inland Printer/American Lithographer, p. 58 (October, 1964).

Latham, Charles W. "How to Solve Problems in Offset Printing," Inland Printer/American Lithographer, p. 52-54 (May, 1962).

Melia, M. C. "Effect of Bending on Sheet Structure and its Relevence to Offset Printing," Paper Technology, p. 435-442 (May, 1965).

Stubbs, D. H. "Pick," American Ink Maker, p. 29, 30, 63, 64 (March, 1966).

Truman, A. B. and M. Jackson. "Breakage of Fiber to Fiber Bonds During the Bending of Paper," Paper Technology, p. 203-209 (March, 1965).

Yochheim, William E. "What Printers Should Know About Uncoated Offset Paper," Inland Printer/American Lithographer, p. 54-57 (November, 1964).

Reports

Albrecht, J. and M. Heigl. "Water, Ink, and Tack," TAGA Proceedings, 17th Annual Meeting, (New York, Technical Association of the Graphic Arts, p. 337-348, 1965).

Anonymous. "Picking Terminology," Technical Service Report 1, (Pittsburgh, Graphic Arts Technical Foundation, 1967).

Anonymous. "Specks in Prints," How Will It Print, Bulletin 2, (Boston, Mass., S. D. Warren Company).

Anonymous. "TAPPI Data Sheets--Press Picking," (New York, Technical Association of the Pulp and Paper Industry, Issue 399.01, 1965).

Baldwin, Harry. "Pressroom Problems Resulting from Various Paper Defects and Changing Press Requirements," TAGA Proceedings, 16th Annual Meeting, p. 182-191 (1964).

Beckman, Norman J. "Bench Test for Predicting the Effect of Fountain Solution on Pick and Curl of Offset Papers," TAGA Proceedings, 11th Annual Meeting, p. 49-66 (1959).

Borchers, Charles. "Studies of Ink Transfer to Paper in Lithography," The Penrose Annual, (London, Percy, Lund, Humphries and Company Ltd., Vol. 51, p. 80-83, 1957).

_______. "Studies of Ink Transfer During Printing," Research Progress 37, (New York, Lithographic Technical Foundation).

Borchers, Charles and William L. Boehm. "Current Studies of Ink Transfer to Paper in Lithography," TAGA Proceedings, 11th Annual Meeting, p. 37-48 (1959).

Fetsko, Jacqueline M. "Sources of Differences in Picking Results Among Presses." (Bethlehem, Pennsylvania, National Printing Ink Research Institute Bulletin 60, 1962).

Jorgensen, George W. "The GATF QC Strip," Research Progress 71, (Pittsburgh, Graphic Arts Technical Foundation).

_______. "The LTF Star Target," Research Progress 52, (New York, Lithographic Technical Foundation).

_______. "The LTF Press Inkometer and the Automatic Control of Press Dampening," Research Progress 58, (New York, Lithographic Technical Foundation).

Kuehn, Albert T. "True Rolling and Cylinder Packing on Offset Presses " (Chicago, Ill., The Miehle Company, 1955).

Preucil, Frank, Zenon Elyjiw and Robert F. Reed. "The GATF Dot Gain Scale," Research Progress 69, (Pittsburgh, Graphic Arts Technical Foundation).

Reed, Robert F. "Hickies and Spots," Research Progress 35, (New York, Lithographic Technical Foundation).

Roehr Walter W. "A Rotary Pick Tester," (Neenah, Wisc., Kimberly-Clark Corporation, 1951).

Schaefer, A. B., A. B. Fisch, and A. C. Zettlemoyer. "Printing Ink-Paper Relationships XIII," (Bethlehem, Pennsylvania, National Printing Ink Research Institute, Report 51, 1963).

Stoessel, Otto C. "Measurement of Ink and Printing Qualities," TAGA Proceedings, 12th Annual Meeting, p. 81-94 (1960).

Unpublished Material

Dunning, E. T. "Development of Tack Graded Testing Inks" (Chicago, Ill., Interchemical Corporation).

Williams, Roger L. "Correlative Accuracy of Offset Print Testing Procedure at Westvaco's Mechanicville, Tyrone, and Luke Mills," (Tyrone, Pennsylvania, Westvaco Quality Control Report, 1966).

Other Sources

Blake, Carl B. Sinclair and Valentine Ink Company (letter to the author, October, 1967).

Clifton, E. A. Dayco Corporation (letter to the author, November, 1967).

Curado, Joseph G. Sun Chemical Corporation (letter to the author, September, 1967).

Denzer, Carl. Institute of Paper Chemistry (personal communication, October, 1967).

Diehl, Robert. Westvaco (personal communication, August, 1967).

Enchelmeyer, William. Borden Chemical Corporation (letter to the author, October, 1967).

Fox, K. Rapid Roller Company (letter to the author, October, 1967).

Gerlach, Werner. Capitol Printing Ink Company (letter to the author, September, 1967).

Leekley, Robert M. Institute of Paper Chemistry (personal communication, October, 1967).

________. Institute of Paper Chemistry (letter to the author, September, 1967).

Marks, Donald. Company X, (personal communication, October, 1967).

Prince, Raymond J. Graphic Arts Technical Foundation (letter to the author, November, 1967).

Quint, Richard J. Oxford Paper Company (letter to the author, November 1967).

Reph, Ronald C. 3-M Company (letter to the author, September, 1967).

Roehr, Walter W. Kimberly-Clark Corporation (personal communication, October, 1967).

Sacksen, Peter K. Weyerhauser Corporation (personal communication, June, 1966).

Snoke, D. O. UniRoyal Inc. (letter to the author, October, 1967).